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RESEARCH ARTICLE

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Global and Regional IUCN Red List Assessments: 13

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Abstract

In this contribution, the conservation status assessment of two vascular plants according to IUCN categories and criteria are presented. It includes the global assessment of *Isoëtes todaroana* Troìa & Raimondo and *Moluccella bucharica* (B.Fedtsch.) Ryding.

Keywords

conservation, extinction risk, IUCN protocol, threats

How to contribute

The text of the global and regional assessments should be submitted electronically to Simone Orsenigo (simone.orsenigo@unipv.it) or to Giuseppe Fenu (gfenu@unica.it); the text, up to 8000 characters in length (spaces included), must include a distribution map and a picture of the assessed species.

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Red List Assessments

Isoëtes todaroana Troìa & Raimondo

Global assessment
Taxonomy and nomenclature
Order: Isoëtales *Family*: Isoëtaceae

Isoëtes todaroana Troìa & Raimondo, Amer. Fern J. 99(4): 238 (2010) = *Isoëtes iapygia* Ernandes, Beccarisi & Zuccarello, Pl. Biosystems 144(4): 807 (2010).

Common name: Calamaria di Todaro (It), Sicilian Quillwort (En).

Geographic distribution range: *Isoëtes todaroana* (Fig. 1) is a perennial amphibious plant described from Sicily (Troìa and Raimondo 2010) and later reported for other localities of Italy and Greece (Fig. 2). This species was found near Mazara del Vallo (Trapani) and its current distribution range in the island is circumscribed to a restricted area in western Sicily. In the Italian Peninsula, *I. todaroana* occurs in Calabria, between Capo Colonna and Isola Capo Rizzuto near Crotone (Bernardo and Peruzzi

Figure 1. *Isoëtes todaroana* Troìa & Raimondo from *locus classicus* (Mazara del Vallo, Sicily). Photograph by S. Cambria.

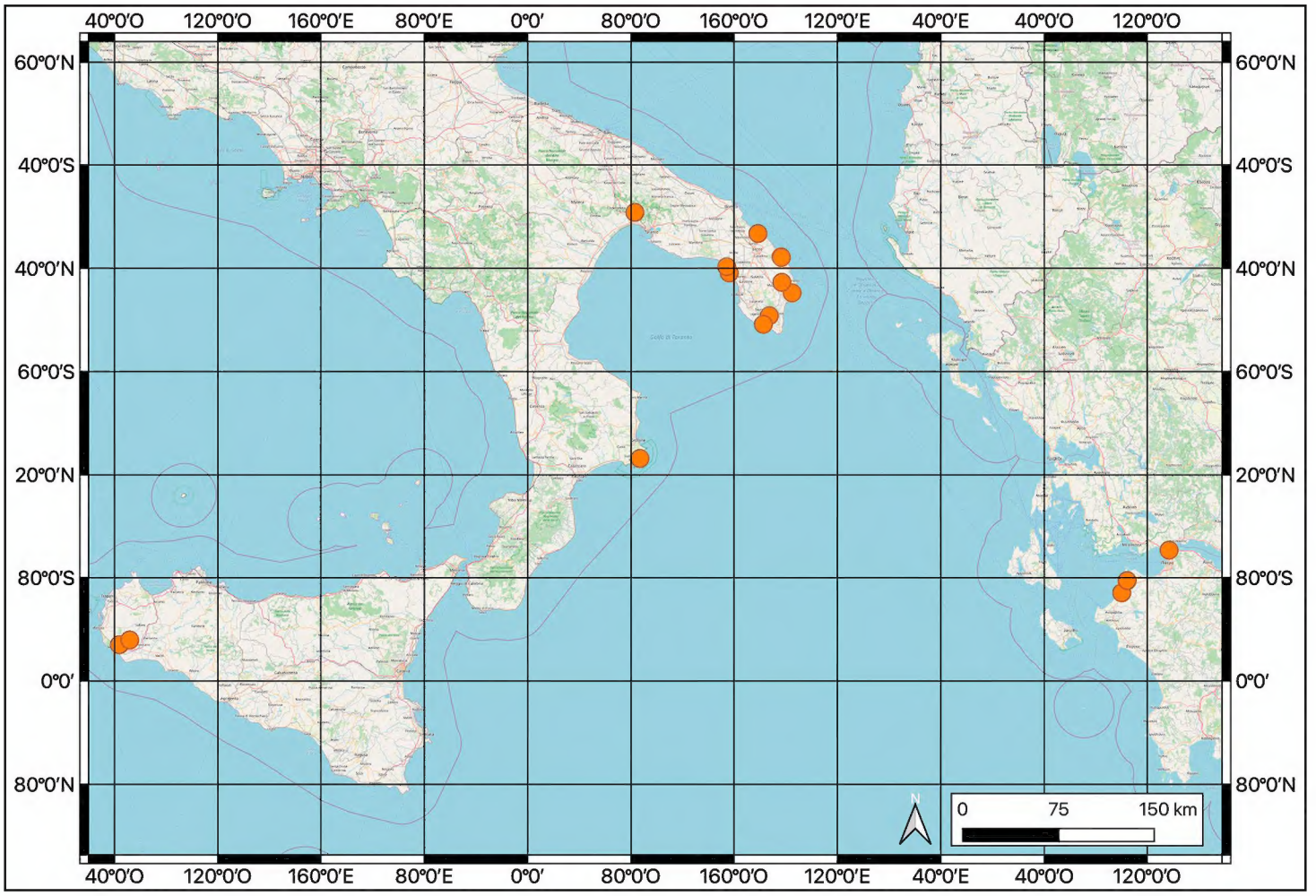

Figure 2. Geographic range and distribution map of *Isoëtes todaroana* Troìa & Raimondo.

2011), and in several localities of Apulia, between Massafra and the province of Lecce (Ernandes et al. 2010). According to Troìa and Greuter (2015), on the basis of verified herbarium specimens (formerly stored under different names), *I. todaroana* has to be added to the Greek flora.

Distribution: *Countries of occurrence*: Italy and Greece.

Biology: *Plant growth form*: perennial (geophyte).

Chromosome number: $2n = 22$ (Troìa et al. 2011).

Phenology: The spores begin to mature throughout March to May.

Reproduction: There is no available detailed information**.**

Habitat and ecology: *Isoëtes todaroana* grows on calcareous sandstone in seasonal wetlands that dry out in summer. It occurs up to 150 m a.s.l.; the community in which it grows is characterized by several hygrophilous plant species, such as *Eleocharis palustris* (L.) Roem. & Schult., *Isolepis cernua* (Vahl) Roem. & Schult., *Mentha pulegium* L., and *Lythrum tribracteatum* Salzm. ex Spreng., *Romulea ramiflora* Ten. From a phytosociological viewpoint, it falls within the *Isoëto-Nanojuncetea* class. It should be noted that the plant communities with *I. todaroana*, which is the characteristic species of the *Isoëtetum todaroanae* association (Brullo et al. 2022), are listed in Annex I of the Habitats Directive as priority habitat type (3170* Mediterranean temporary ponds).

Population information: This species shows a central-Mediterranean range with a narrow distribution in few stands. The Italian distribution is limited to 13 sites in southern Italy and Sicily, while only three sites are reported on mainland Greece (Troìa

and Greuter 2015). Usually, for each site, there is a small number of mature individuals, due to the limited extension of seasonal wetlands. Detailed information on the number of existing individuals is lacking.

Threats: *2.3 Livestock farming and ranching (nomadic grazing)*: Agricultural activities (farming and grazing) are the most relevant threat to this species. In particular, trampling by livestock and their droppings modify the natural habitats.

6.3 Work and other activities: Human pressure causes the disappearance of temporary wetlands, especially when these areas are reclaimed and converted to farmland, as can be seen in the type locality of *I. todaroana.*

11.2 Drought: the conservation of *I. todaroana* depends on the presence of temporary pools and, therefore, their drying up due to high temperature causes the rapid disappearance of the species.

CRITERIA APPLIED

Criterion B: **AOO**: 64 Km^2 calculated with GeoCAT (Geospatial Conservation Assessment Tool) programme (Bachman et al. 2011).

a) Number of locations: 10. The species is distributed in several localities of the Mediterranean basin, but its habitat is often fragmented and circumscribed to small areas of a few square meters. Although the most important threat is represented by agricultural activities (farming and grazing), as well as the conversion of the wetlands to farmland, drought could also threaten *I. todaroana*, causing the disappearance of suitable habitats.
b) According to field observations and literature data, habitat quality (iii) is in continuous decline, and a reduction of AOO (ii) is likely to have affected the species.

Red List category and Criteria (Global Assessment)

VU	**Vulnerable**	**B2ab(ii,iii)**

Rationale for the assessment: The populations are scattered in the Mediterranean area and are linked to humid habitats. Because of the presence of few individuals per stands and the significant reduction of the wetlands size, a future decline of this species is likely. Based on recent research and field investigations and according to its AOO of 64 km^2 and the number of locations (10) this species can be assessed as Vulnerable (VU).

Previous assessment: This taxon has been previously evaluated as critically endangered (CR) at a global level (Christenhusz et al. 2017a; Garcia Criado et al. 2017), but taking into account only the Sicilian populations, and considering *Isoëtes iapygia* as a distinct taxon (evaluated as vulnerable, VU, by Christenhusz et al. 2017b). At a regional level (Italy), this species (including *I. iapygia*) has been assessed as Endangered (Orsenigo et al. 2018).

Conservation actions: *Isoëtes todaroana* is not protected by international, national, or regional laws. Some of the currently known populations of this species fall within protected areas. In Italy, it grows in the following SACs (Special Areas of

Conservation, according to Habitats Directive 92/43/EEC): "Sciare di Marsala" (Trapani, code ITA010014), "Area delle Gravine" (Taranto, code IT9130007), "Palude del Capitano" (Lecce, code IT9150013) and "Rauccio" (Lecce, code IT9150006), while in Greece only one locality is included in the SAC named "Limnothalassa kalogrias, dasos strofylias kai elos lamias, araxos" (code GR2320001). Note that the *locus classicus* was not included in a protected site when the species was described, its inclusion was regarded as being desirable by Troìa and Raimondo (2010) who described the species, and formally proposed two years later, becoming recently effective .

Conservation actions needed: The restoration of degraded ecosystems is recommended in order to preserve the plant communities where *I. todaroana* grows. To maintain the natural habitats, the conversion of wetlands into farmland has to be forbidden. Furthermore, *in situ* and *ex situ* conservation strategies are needed for possible plant translocation activities, with the objective of increasing population sizes.

Notes: The actual distribution range of the species was unclear, especially in Italy, since shortly after the publication of *I. todaroana*, another quillwort was described from Puglia as *I. iapygia* (Ernandes et al. 2010), which is currently considered as a heterotypic synonym (Troìa and Greuter 2015). This species is apparently similar to the well-known Mediterranean terrestrial species *I. histrix* Bory and *I. durieui* Bory, but actually belongs to another lineage, including the western Mediterranean *I. delilei* Rothm. and the eastern Mediterranean *I. phrygia* (Boiss.) Hausskn. (Troìa et al. 2019).

G. Tavilla, S. Cambria, A. Troìa

Moluccella bucharica (B.Fedtsch.) Ryding

Global assessment

Taxonomy and nomenclature

Order: Lamiales *Family*: Lamiaceae

Moluccella bucharica (B.Fedtsch.) Ryding, Taxon 60: 48 (2011) ≡ *Otostegia bucharica* B.Fedtsch., Izv. Imp. Bot. Sada Petra Velikago 15: 2 (1915)

Common name: Otostegia Bukhara (En).

Geographic distribution range: *Moluccella bucharica* (Fig. 3) is endemic to gypsum areas of the south-western Pamir-Alay (Uzbekistan). It is restricted to the foothill areas of the western Hissar ridge, with a narrow altitudinal range between 1,150 and 1,450 m a.s.l. Currently, this species has only two subpopulations 7 km away from each other: the largest is located in the gypsum foothill area near the villages of Derbend-Shurob, and the smallest around the village of Gurkhozhi (Fig. 4).

Distribution: *Countries of occurrence*: Uzbekistan.

Biology: *Plant growth form*: Shrub (nanophanerophyte).

Flowering and fruiting time: flowering from May to July, fruiting from July to August.

Figure 3. *Moluccella bucharica* in south-western Pamir-Alay (Surkhandarya). Photograph by B. Khabibullaev.

Reproduction: no information on pollination and dispersal strategy is available. The number of seeds per individual is variable, but overall, 85% of seeds produced are damaged by pests (Khabibullaev et al. 2022); germination rate of seeds in the laboratory is 0.001% (1/1000).

Habitat and ecology: *Moluccella bucharica* is a rare shrub (up to 120–150 cm) that grows on gypsum-rich areas, at an optimum elevation range from 1,100 to 1,500 m a.s.l., in the driest and hottest southern region of Uzbekistan (Surkhandarya region). In the foothills where it grows, the average annual temperature is in the range of 11.7–13.9 °C, with an average annual rainfall of 205 mm (1980–2020). In the hottest summer months, the average maximum temperature is 21.1 °C and the soil temperature rises to 65 °C, while in the coldest winter months, the average minimum temperature is 6.21 °C and the soil temperature can drop to -20 °C (Sparks 2022). The habitat of *Moluccella bucharica* is restricted exclusively to gypsum soils (Khabibullaev 2020), colonized by plant communities mainly dominated by *Prunus spinosissima* (Bunge) Franch., *Zygophyllum atriplicoides* Fisch. & C.A.Mey. and *Artemisia sogdiana* Bunge.

Population information: The existing subpopulations of *M. bucharica* grow in very small, isolated areas on chalk foothills. The number of adult plants in 1977 was 2,860 in three subpopulations (Belolipov 1980); in 2005 a total number of 1,974 individuals was counted, while in 2006, 2007, 2008, and 2018 the subpopulations were monitored but the individuals were not counted (Tojibaev et al. 2019). Currently,

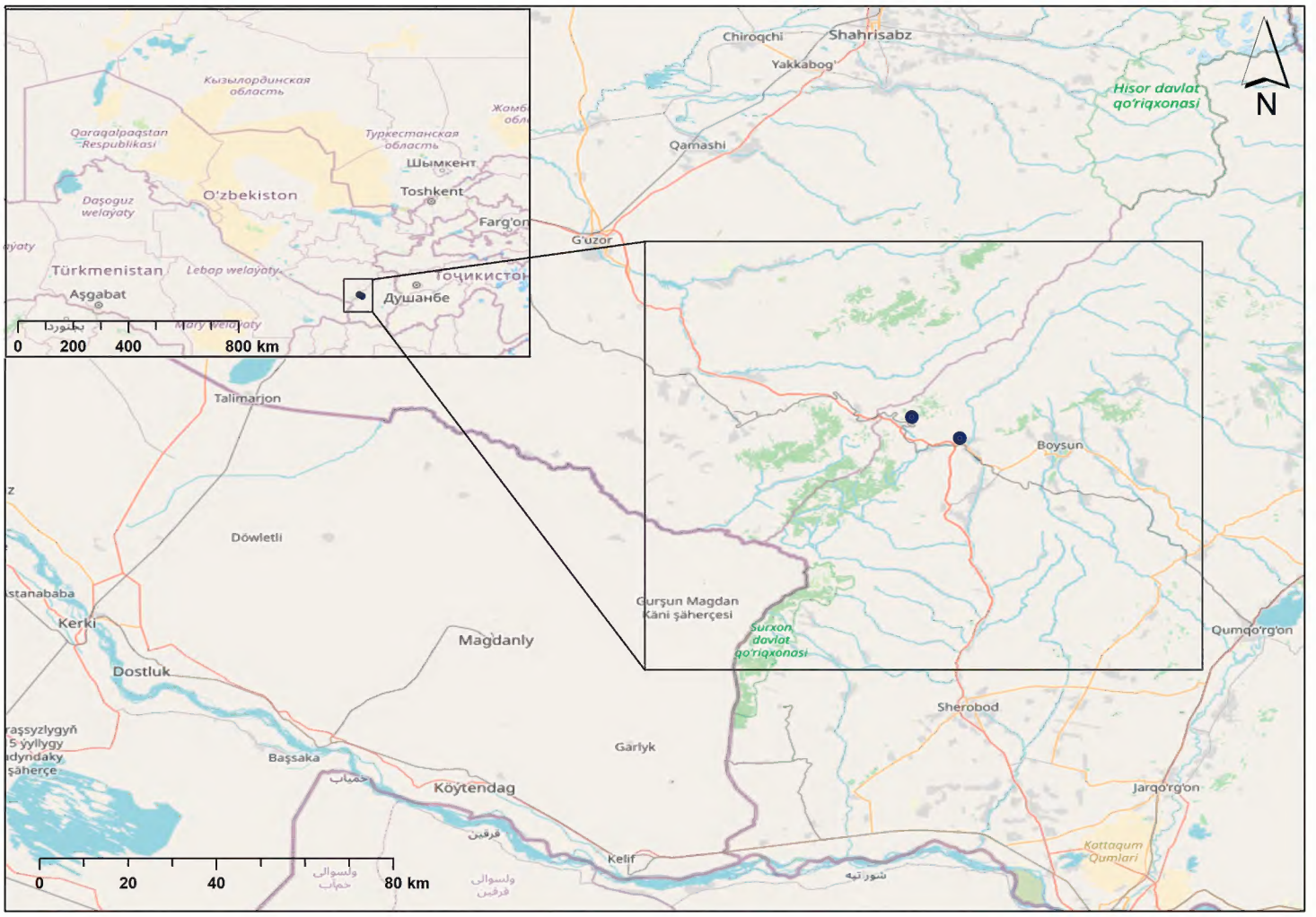

Figure 4. Geographic range and distribution map of *Moluccella bucharica*.

only two subpopulations are preserved, with a total of *c.* 600 plants, 570 of which are mature individuals (95% of the total); in the subpopulation in Derbend-Shurab, there are about 400 individuals (of these 380 are mature), and in the subpopulation in Gurkhozhi 200 individuals (of these 190 are mature). During the last 20 years, these subpopulations have been subject to large changes in population size, cover, and density. Belolipov (1980) did not observe any renewal from seeds during the previous 15 years. From unpublished work carried out at Levichev's Botanical Institute in 1987 on the seed renewal of a population growing along a pedestrian route 5 km in length, not a single seedling was observed. However, 3- to 4-year-old individuals were detected, obviously being of seminal origin (Tojibaev 2009). The overall trend of the population size and the number of mature individuals is decreasing due to the numerous threats affecting the species.

Threats: 1.1 *Housing & urban areas*: Due to the increase in the rural population, houses under construction have approached the plant populations by 20 meters, resulting in a potential negative impact.

2.3 Livestock farming & ranching (2.3.1 Nomadic grazing): the mountainous areas where the species grows are used by the local population throughout the year as pastures for livestock. Livestock grazing leads to severe damage to *M. bucharica* branches and the destruction of young individuals. In addition, there is non-irrigated agricultural land around the population of Shurob.

4.1 Roads & railroads: Large-scale road construction and geological prospecting also have a negative impact on the populations of this species. In 2005, part of the *M. bucharica* subpopulation was translocated as a result of a rail transfer from the area where the species grows (Tojibaev et al. 2019).

5.*2 Gathering terrestrial plants (5.2.2 Unintentional effects [species is not the target])*: Like many fuel plants, *M. bucharica* is harvested by locals for firewood.

7.3 Other ecosystem modifications: The number of pests in the ecosystem has increased dramatically. As a result, the percentage of damage to *M. bucharica* seeds has also increased. The proportion of ruderal species in the plant community has increased due to grazing (Shomurodov and Khabibullaev 2022).

11.2 Droughts: Based on the last 39 years of meteorological data (Khabibullaev et al. 2022), the trend towards a more arid climate in the locality of *M. bucharica* continues; air temperature rises by 0.27 °C every 10 years and moisture deficit increased up to 28% in the warm half of the year (e.g., in 2001 there was 87.5 mm of precipitation as compared with 299.46 mm in 1997).

11.3 Temperature extremes: The amplitude of the change in the average, maximum and minimum air temperature in the territory is high (Khabibullaev et al. 2022).

CRITERIA APPLIED

Criterion A: a continuous decline of the population of *c.* 80% was observed over the past 45 years.

Criterion B: **EOO**: 8 km^2 calculated with GeoCAT (Geospatial Conservation Assessment Tool) software (Bachman et al. 2011).

AOO: 8 km^2 calculated with GeoCAT software (Bachman et al. 2011).

a) Only a single location (unsystematic grazing and its use as fuel by the local population).
b) Continuing decline in extent of occurrence, area of occupancy, extent and quality of habitat, number of locations and subpopulations, and number of mature individuals.
c) No extreme fluctuation observed.

Criterion C: the global population, in continuous decline, is currently composed of 570 mature individuals and no subpopulation has more than 1,000 mature plants.

Criterion D: the global population comprises fewer than 1,000 mature plants.

Red List category and Criteria (Global Assessment)

CR	Critically Endangered	B1ab(i,ii,iii,iv,v)+2ab(i,ii,iii,iv,v) + A2(a,c)

Rationale for the assessment: *Moluccella bucharica* is endemic to a small area, with an EOO and AOO of 8 km^2, only one location could be identified according to major threats, and a decline in habitat quality, AOO, EOO number of location and subpopulations of this species was observed. The global population consists of 570 mature plants, and a continuous decline of the population of *c.* 80% was observed over the past 45 years. Climate change is projected to further reduce the available habitat of this high-elevation restricted

species. Although criteria C and D allow to assess the species as vulnerable (VU), *M. bucharica* should be assessed as Critically Endangered (CR) according to criteria A and B.

Previous assessment: This taxon is evaluated as Critically Endangered (CR) at the global level (Khabibullaev et al. 2021).

Conservation actions: *Moluccella bucharica* is included in the Red Book of the Republic of Uzbekistan with category 1 (on the brink of extinction) (Kuchkarov et al. 2019). However, the area where it is distributed is not part of a reserve. To protect this species from further decline by reducing habitat loss and fragmentation, the protection of sites and the limitation of overgrazing and logging are recommended. To restore the population of *M. bucharica*, it is necessary to create a protected area that includes its growing sites, raise awareness of the local population, and conduct regular monitoring. Currently, experiments are being conducted in the Tashkent Botanical Garden on the reproduction biology of the species. Measures should be taken to control pests that damage the seeds.

Conservation actions needed: Research and monitoring programmes are recommended in order to better understand the reproductive biology and population trends of this species. In addition, *in situ* and *ex situ* conservation measures are suggested for potential plant translocation programmes, with the goal to increase the low number of individuals in the population.

G. Fenu, K.F. Shomurodov, B.S. Khabibullaev

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